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JUDITH H. ALLTON
INTERVIEWED BY JENNIFER ROSS-NAZZAL
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The questions in this transcript were asked during an oral history session. Ms. Allton has edited and revised the answers. As a result, this transcript does not exactly match the audio recording.

ROSS-NAZZAL: Today is October 12, 2017. This interview with Judy Allton is being conducted at the Johnson Space Center for the JSC Oral History Project. The interviewer is Jennifer Ross-Nazzal, assisted by Sandra Johnson. Thanks again for coming in this afternoon and walking across campus. My car said it was 91 degrees when we walked back, so we appreciate you coming over.

Today we were going to talk about the Genesis Discovery [Program] mission. I was curious how you got involved with that mission.

ALLTON: It was an opportunity for me to participate in a flight mission. As you know, I've worked with the lunar samples for a long time, but I didn't participate in actually collecting those since I didn't come until '74. This was an opportunity to see how you prepare something to fly and how to make it work.

Also the planetary science community was very interested in determining the precise solar composition. All the studies on the lunar rocks and meteorites and other planetary bodies really needed to know the elemental and isotopic composition of the starting material, the solar nebula, thought to be captured in the Sun's composition. There were a lot of science folks who thought, "Wow, that's going to be critical information."

I was asked to participate in Genesis by Eileen [K.] Stansbery, who is currently JSC chief scientist. Eileen became the contamination control officer for this mission, even though Genesis was managed at [NASA] JPL [Jet Propulsion Laboratory, Pasadena, California]. The spacecraft was built by Lockheed Martin [Corp.], but JPL built the payload containing the solar wind collectors.

This, as the Discovery missions are, was a PI [principal investigator]-driven mission. The principal investigator was Don [Donald S.] Burnett of Caltech [California Institute of Technology, Pasadena, California], who's done a lot of work making laboratory measurements on lunar and meteorite rock chemistry and isotopes. He had been very keen to determine that key piece of information—the solar composition as determined by direct measurement of solar matter. Previously, estimates of solar composition were derived from meteorite analyses.

All of the people on the Genesis Science Team are precision chemists in the lab, and persnickety, especially isotopers, who work in ultraclean laboratories. They have a reputation for washing down the lab walls and suiting up in cleanroom garments to keep the room clean. I came from that background, because my background is chemistry and isotope geology, and I worked in the Lunar Lab, which we keep in pristine shape. In the Lunar Lab, we care about the chemical composition of the paint on the wall, the floor, etc., because certain trace atoms can interfere with the age dating for Moon rocks.

So I had the mindset, I think, of being a persnickety chemist, and Don Burnett was an amiable guy. I respected his work a lot, Eileen's also. He picked Eileen to be contamination control officer, and that is what made this Discovery mission, I think, unique in a lot of respects, even though the mission was managed by JPL. Genesis was unique by funding sample curation and allocation included in the proposal, and unique in performing the cleanest payload assembly in ISO [International Organizations for Standardization] 4 (Class 10) environment. That Don and the science team expressed confidence in the curation expertise and long experience by JSC Astromaterials curation was indeed a compliment!

Those Discovery missions were smaller than flagship missions. Right now I've been peripherally involved in some of the Mars 2020 meetings, and that program involves a lot of people. The management structure is quite large, but Discovery mission management was small, with closer professional relationships and respect among team members.

By all accounts Don Burnett worked very well with the JPL management, had some input into who was going to be on the JPL engineering team, and, between him and the JPL managers they chose excellent team members. It worked out very well. The engineers cared about the science, the precise composition of the Sun, and did their very best to make it work. Don is a real hands-on principal investigator, checking details. Not all of the Discovery mission PIs were. Don would call up and ask what we were doing. He would suit up and come into the lab. He visited all the laboratories operated by the science team, which was comprised of leading planetary scientists world-wide. It wasn't a very—what do you call when you—?

ROSS-NAZZAL: Hierarchical?

ALLTON: Right. Anybody could talk to anyone else on a first name basis. Everybody who had hands-on access to the hardware to be used for collecting these samples pretty much understood what science results were going to come out of the mission, and that they had to be very careful about contamination control. It was a team built on mutual respect.

ROSS-NAZZAL: You mentioned it was unique because it was a smaller group. Do you recall about how many folks were participating in this mission?

ALLTON: If I think back to the telephone list we used, there were about 250 people across groups at JPL, LMA [Lockheed Martin Astronautics], LANL [Los Alamos National Laboratory, New Mexico], JSC, UTTR [Utah Test and Training Range], KSC [Kennedy Space Center, Florida], and, of course, the science team members from various universities. The largest number of people were at JPL and LMA. JPL managed the mission, mission design, navigation, and payload design and fabrication. LMA built the spacecraft and sample return capsule (SRC), and controlled the mission during flight from their control room in Denver. Los Alamos people built and calibrated the concentrator, an active collector that concentrated ions of the principal science goals—O, N, C.

People at KSC were involved with launch, and people at UTTR were extremely helpful during recovery, especially after the parachute deploy failure and resulting hard landing. I should talk later how the UTTR people furnished all kinds of help in salvaging the payload, they are a real "can do" outfit. Karen McNamara was the JSC curation point-of-contact working with UTTR folks to prepare for recovery in 2004.

Burnett and his science team, about 30 people, and JSC contamination control team, about 10 people, were invested in the mission from beginning to end. At time of Genesis launch in 2001, Burnett had been working on Genesis and its first-attempt proposal called Suess-Urey for about 20 years. [The Suess-Urey mission was named after two prominent scientists in the field of cosmochemistry—Drs. Hans E. Suess and Harold C. Urey]. The original science team members defined the collector materials in the 1990s. I also count, from people I worked with directly, about 15 payload people from JPL, 5-10 people from LANL, and 10-15 recovery people from LMA as being involved from mission design through hardware fabrication, cleaning, assembly, flight operations, recovery and allocation of samples to investigators. Having these long-term relationships was very useful during the sample analysis period, which still continues today, because I often consulted the payload and spacecraft people concerning materials which might be contamination sources on the surfaces of the collectors. This is a unique strong point of Genesis planning and teamwork.

Materials scientist A. J. G. (Amy) Jurewicz is an example of someone involved long-term with Genesis. She was the Genesis project scientist at JPL pre-flight and most knowledgeable about the collector materials. She continues to be the “go to” person as we document how the collected materials were subtly changed by the space radiation environment.

We at JSC were mostly concerned with cleaning and assembling the payload in [Federal Standard 209E] Class 10 conditions. Today it would be ISO Class 4. It’s very clean. We suited up entirely, and in those days we had Teflon-coated suits, with helmets. Everything exhausted, that you breathed out or that came off your body, went through a HEPA [high efficiency particulate air]-filter on the back. It was like a lightweight spacesuit, but it wasn’t a pressure suit. It was merely to keep people from shedding into the lab.

We built the lab here at JSC because we had extensive experience in cleaning hardware associated with science samples. So the JPL payload engineers arrived at JSC with their payload. We and they took it apart. We cleaned the parts. They put it back together, but it was a well-integrated process, a smooth interaction. The JPL folks came to Texas in August and stayed here for months. Their processes were very different than ours. For Eileen Stansbery and I, it was an interesting difference, watching the meeting of cultures.

I can remember when the people from JPL showed up with a truck, with their payload in it in hot weather here. They stepped out wearing their Hawaiian shirts, Bermuda shorts, and sandals, and here we were in our blue jeans. Jack [L. Warren] had a gimme [baseball] cap on. It just looked like two cultures meeting each other.

They came from a place where they do big missions. They put spacecraft together in enormous, multistory clean rooms that weren't really so clean by our standards. We asked them to work in a room that had only an eight-foot ceiling height. Because the top of the room was covered with ULPA [ultra low penetration air] filters, and the air would go straight down through the floor and then back up the sidewall. We had a laminar flow that would sweep particles down and away, but the ceiling wasn't very high.

They were pretty good sports, because we said, "Now all of you have to work in this not-too-high ceiling room. You have to wear this suit, which completely encloses your body. The head gear encloses your face and allows vision through a plastic face shield, the suit motor pulls all exhaled breath and particles shed from your body through a small HEPA filter, and gloves and boots complete the enclosure. When you install screws in the hardware, you can't touch the screws with the gloves, you have to use tweezers." They were either good actors or good sports, because they did it without grumbling.

They had new rules for us as well. JPL is very careful about controlling electrostatic discharge during spacecraft assembly because it can cause undetectable damage, so we had to take ESD [electrostatic discharge control] training and become sensitive to ESD safe protocols.

In addition to assembling a payload in Class 10, we were cleaning the hardware with ultrapure water (UPW). Measuring the carbon isotope composition of the Sun was one of the science goals. We felt like organic solvents would leave some organic residue, so the final cleaning was just water that's very, very pure – ultrapure water. UPW has very high resistivity and acts a little bit like an acid, a little bit like a base. It is "hungry" water and removes many contaminants without leaving a residue. Our UPW production was 10 gallons per minute.

The JSC team cleaned the payload hardware in one cleanroom. There were only about five of us that did all that work. We felt like the *A-Team* [television series] or Skunk Works [Lockheed Martin Advanced Development Programs]. We would work right into the night. We would go out to the hardware store or other places and buy equipment needed to make the lab work using our own money. We have one picture of people scrubbing the threads on very tiny screws. Everyone is fully suited up, and the "dishwashers" were 2 PhDs and a Master's level geochemists. Because everybody put in a lot of effort, it was team-building work. That's the JSC side. We would hand-off the cleaned hardware to the JPL team in assembly cleanroom.

We started every day with a meeting to review actions. Eileen Stansbery set that up. The JSC-JPL team just worked really well together, because there weren't very many of us. There were about four or five of them, and there were about four or five of us. There were some problems getting hardware cleaned and assembled but that got worked out. That was getting ready for flight. I note here that the families of everyone working this mission deserve credit for mission success because of the long hours required. People who work flight missions know this.

Finally, all was cleaned and assembled. Then the payload canister, containing the 300 solar wind collectors, was closed for the final time in this room. Everybody present and watching was enclosed in Teflon fabric suits with faceplates. I thought, "The arrays with the polished collectors are so beautiful. Wow, I wonder what it will look like when we get it back." Genesis was supposed to be launched in 2000 but didn't get launched till 2001. Genesis re-entered Earth in September 2004. I was there in Utah for the return September 8, 2004, at 10 a.m. Genesis had been parked in a halo orbit at Earth-Sun L1 and was open to collect solar wind for about 27 months. That was just barely enough time to gather enough solar atoms in these collectors so people could make solar wind measurements above background level. All of Genesis involved cutting-edge analytical challenges.

ROSS-NAZZAL: I wanted to go back and ask a couple questions. You mentioned Eileen Stansbery. She approached you with the possibility of working on the team?

ALLTON: She did. I was at an age where I thought I could do anything.

ROSS-NAZZAL: How did you come up with that contamination control document? Just being over at the old LRL [Lunar Receiving Laboratory] today was amazing. I'm thinking about all the things that went into contamination control. You have a much smaller space, but you obviously had to think about all of those things. Can you talk about how you started, and how that idea evolved?

ALLTON: For contamination control procedures and processes?

ROSS-NAZZAL: Yes.

ALLTON: Actually started after the LRL. The rocks were moved out of the LRL, because in general the geology people felt they couldn't keep it clean enough because of the materials and animals required by the hazard detection people. Plus, the geologists wanted to keep the samples under positive pressure nitrogen, which is what they did after quarantine was no longer required. They designed the building that's now 31N especially for the purpose of keeping the lunar rocks clean and pristine, and it was done by a committee of about five planetary scientists. Most of them were isotopers because they're picky about keeping labs clean, and all of them had built ultraclean laboratories. Two of these lunar facility committee members are notable not only for detailed attention to the new lunar facility back the 1970s, but also for their long service to Genesis mission serving, until recent time, on the oversight committee for allocations of Genesis samples: Dimitri [A.] Papanastassiou and Laurence [E.] Nyquist.

The lunar facility committee worked closely with the engineering people on Building 31 to screen the elemental content of the flooring, the paint, and the wires that plug into the lights. For example, this subcommittee required that the brass plaques identifying doors as fire-rated doors be removed from the doors for contamination control reasons; brass is composed of elements that interfere with science results. It was very tightly managed. Everyone who worked there was focused on not bringing certain elements into the lab where they could inadvertently get in the samples. My chemistry background was helpful in this respect.

While I worked in the Lunar Lab, one of the things I did was dissect lunar cores. The drive tubes from the last three missions are the main ones that I worked on. To get those out of the tube takes a lot of equipment, which is assembled inside of a nitrogen-filled glovebox inside of a cleanroom. We had detailed procedures because the assembly had to be done in a precise sequence. Extrusion and dissection of Apollo drive tube samples was a controlled and documented process with attention to detail. We used the same thing approach to define what we should do for Genesis, which had even more stringent contamination requirements.

We put that laminar flow clean room on the first floor of the Lunar Sample Building (Building 31N). We did not have enough money or time to build a new lab for Genesis. But we chose the Lunar Sample Building location because I figured—or maybe Jack and I did—that that building would not blow away in a hurricane. As you know, the lunar sample facility is very solidly built. The lunar samples are up above what was the predicted extreme storm surge at that time. For the Genesis Lab we chose a space on the first floor directly below the Pristine Lunar Sample Lab, because the building was solid, and it was built out of materials compatible with Genesis contamination control requirements.

ROSS-NAZZAL: You mentioned the Teflon suits that you wore and the faceplates. Was that something that was on the market? Or was that something that you had to look at and develop? Was there other hardware or tools that you had to develop unique to that lab?

ALLTON: No, those suits were on the market. The brand name was Dryden suits. I say Teflon, you're probably picturing something like a Teflon bag and crinkly. It wasn't that. It was actually—I think it was a polyester fabric. It just had a Teflon coating on it. That was used to cut down on particles being shed off the suit. I think they may make something similar now. Just recently we started getting rid of the old Dryden suits because those things have a certain shelf life. After Genesis crashed, we just worked in regular full suits with only eyes exposed, without the HEPA filter headgear. It didn't seem to be required after we had retrieved collectors off the desert floor. Some new labs are looking at similar suits now. Those suits are not as common.

We were riding the crest of the semiconductor industry innovation when we put Genesis Lab together. They're very conscious of operating low-particle labs. People are very dirty, they shed about 7 pounds of skin and hair annually. Those suits were used in semiconductor industry in ultraclean labs, back around 1998 when we were putting the lab together.

The industry has moved on. Now there's more robots and less people, so the need for those suits is not what it once was. I don't know if we could find the same thing again. Similar suits have gone into the medical-surgical arena. I'm not sure they'd be exactly the same.

ROSS-NAZZAL: You had talked about cleaning that container when JPL brought that payload out. Were there some other cleaning solvents that you may have used before that? How big of a container are we talking about? How long did that whole process take?

ALLTON: The payload itself was the shape of a tuna can, about 30 inches across, about 18 inches high. It opened with a hinge, like a clam shell, and it was constructed of bare aluminum. A lot of spacecraft designers will finish off their aluminum parts with anodized finish, but anodized finish is kind of porous and can trap a lot of contamination, so Genesis did not use anodization surface treatment on the interior parts next to the collectors. On the exterior, the cover top was painted white for thermal management, and the bottom was anodized.

This was the first experiment that I know of—I think it was the first payload ever assembled in an ISO Class 4 clean room. The aluminum did not have an anodized finish on it, or any kind of finish. We cleaned it with the water. I'm sure we created some aluminum oxide on there, and in fact if you use too hot a water it would get a little bit brown. We were careful with that. But we could get the particle counts down really low to level 25, when you collect the rinse water on those two big pieces.

We had an ultrapure water tank that was a little bigger than the tuna can. It was taken down to its piece parts. The lid, with exterior white paint, and the bottom, with exterior hard anodize, were not submerged. For those we had a wand that would take the ultrapure water and put megasonic energy in it, so you could hose down those two large pieces, with very clean water that had been megasonically energized and would lift particles off.

ROSS-NAZZAL: What does that mean? I don't understand what that means.

ALLTON: Many labs submerge hardware to be cleaned in ultrasonic cleaners. The ultrasonic energy loosens the particles so they can be washed away. Megasonic is a higher energy level. The cleaning effects are slightly different than ultrasonic. Our device provided a shower of megasonically energized ultrapure water aimed at the object to be cleaned. It's like taking a shower versus taking a bath. In the bathtub you're sitting with the dirt, in the shower the dirt is washed down the drain. There was that difference. By particle counts that we took, it worked really well, getting these large, odd-shape pieces particle-free and cleaned up.

ROSS-NAZZAL: How long did that process take you?

ALLTON: Trying to recall the dates. If we were to clean one piece, like the bottom or the top, it would be a daylong thing: getting it in there, cleaning it up. Then you had to take nitrogen jets and dry it. All of this was in a fairly particle-free room. You'd set that out overnight. It would be ready to assemble the next day.

ROSS-NAZZAL: Did you say this was also manufactured in a clean room? So if it was, what was the idea or the intent behind having to clean the equipment again?

ALLTON: I think payload parts were manufactured in a regular machine shop, perhaps with care to keep it clean. Additionally parts arrived from JPL cleaned and bagged, but their typical flight cleaning requirements were not sufficient to meet the science requirements.

ROSS-NAZZAL: Oh, it was. Okay.

ALLTON: We did some precleaning on it, you know wiping. We actually used a little bit of surfactant. In this case it was Joy [dishwashing liquid], two drops of Joy in a whole pan of water, but that was just to get handling debris off of it.

ROSS-NAZZAL: There was concern about contamination. Is that why it had to be clean? Were you concerned about bringing life here and sending it to the Sun? I'm just curious about that.

ALLTON: We weren't concerned about biology. It's just that small particles of any kind, if they got onto the collector surfaces, would make it harder to analyze the solar wind. Most of the solar wind collection surfaces were highly polished. Most of them were silicon wafers. That was a semiconductor product of the time. It's another reason Genesis happened at the right time to match the semiconductor industry. They were making a lot of very pure silicon wafers and they knew how to get them superclean.

We didn't actually clean the polished wafers that we bought. They came off a process line from the suppliers that produced the cleanest wafers. Science team members analyzed several samples and determined who provided the purest, cleanest wafers.

Those arrays, on which the mirror polished hexagonal-shaped wafers were mounted, were objects of beauty! This was an interesting lesson in the value of contamination control personnel having "eyes on" the fabrication processes. The arrays were delicately and precisely carved out with a process called electric discharge machining (EDM), which is a wire that cuts the metal using high voltage and is a relatively dirty process. Metal particles from the wire become embedded in the cut piece. These process details are not always obvious to the contamination control monitors, nor the science effects straightforward to the engineers tasked with fabricating the hardware.

When cleaning the array frames at JSC, this problem was detected and mitigated by resurfacing the array frames. Residues of copper and zinc from the cutting process were detected by analysis of the cutting coupons collected and archived during fabrication. This example illustrates the value of acquiring and archiving reference and witness materials, for which Genesis curation is recognized. For Genesis we archived several kinds of reference materials: samples of all the materials used in constructing the Class 10 lab. This includes paint, fireproofing, flooring, caulk, and gaskets. Samples of spacecraft components: spare fasteners cleaned for flight, bags, RTV [room temperature vulcanizing] staking compound, lubricants, cutting oil, array frames including the outfall pieces from the EDM, engineering model spares. Most important reference materials were the non-flown collectors. These are critical for background measurements for analyzing solar wind collectors. In fact, over the years we have allocated 600 fragments of solar wind collectors and over 300 reference collectors. All of these reference materials are tracked in a database, just like Genesis-flown collectors.

We were careful about clean hardware adjacent to the solar wind collectors. Micrometeorite impacts from interplanetary dust might hit the aluminum frame and splatter frame material on the collectors. That's one reason we were so picky about everything that went into it.

ROSS-NAZZAL: It sounds like it. You mentioned the suit. I'm just curious because also when we were over at [Building] 37 mentioned how every time somebody left that building they had to take a shower. Did you have other requirements beyond donning a suit for going in there?

ALLTON: No, we actually had people change out of their street clothes and put on scrubs under those suits just to keep from dragging particles from street clothes into the lab. Also that was cooler than most street clothes. The suits didn't breathe all that well. Our precautions were for the purpose of keeping the interior of the suits clean and personnel comfort. The LRL procedure was for the purpose of containment of potential biohazards inside the LRL.

ROSS-NAZZAL: I can imagine with Teflon on.

ALLTON: Because the clean room—the air coming from the ceiling to the floor travels at 100 linear feet per minute. So what does that make, 12 air changes a minute? That "vertical breeze" cools things off a lot just because the air is moving. In the LRL the scrubs were the lab outfit.

They made people take off everything and put on laboratory-furnished scrubs. They had to take off everything and shower out before they could leave. They were just trying to make sure no one carried anything hazardous out of the lab.

ROSS-NAZZAL: Did you ever go visit any clean labs in Silicon Valley as you were creating this lab? Or did you just read up on literature and decide, "These are the things that we need to have as we're constructing this lab"?

ALLTON: We attended—between Eileen, Jack, and I—several semiconductor conferences. They provided clean room classes, suit classes, air shower classes. We went to the trade shows. That's where we got our megasonic cleaner that we used and the cascade tanks. Most of those things were not very expensive. Back in those days several semiconductor trade shows were in Austin, so we could drive. It was very economical.

ROSS-NAZZAL: So most everything was off the shelf. It wasn't anything newly created for JSC?

ALLTON: Most of our equipment was off the shelf, and one Genesis contribution was adapting ultrapure water for cleaning flight hardware and assembling the payload in a Class 10 environment. After the crash, we made another significant contribution by adapting a wafer spin cleaner and using it to megasonically spin clean selected Genesis collector fragments. That works well.

ROSS-NAZZAL: How did you come up with that idea?

ALLTON: Using the spin cleaner to clean contaminant particles from Genesis samples, after the crash, was the idea of Michael [J.] Calaway. Using UPW to clean hardware was driven by the need to discontinue using Freon 113 to clean lunar tools. We had an enormous Freon still that was, I don't know, six or eight feet high. Our metal parts that we cleaned for tools and containers for use in the lunar cabinets would be cleaned with Freon. Every once in a while we find a piece of hardware that was cleaned with Freon years ago and still bagged. Of course we haven't used Freon in decades, but the Freon-cleaned pieces are exceptionally clean.

When we had to move away from Freon, we moved to was ultrapure water. Curation built an ultrapure water system. It's a water plant. It's equivalent to Milli-Q water that people use in small quantities in labs. The resistivity is high, over 18-megaohm. We had several hundred feet of piping, supplying several labs, producing about eight gallons a minute. We produce enough to flush lunar glove boxes, meteorite glove boxes, clean hardware with UPW water heaters. We had that in place already. Don Burnett, thinking he didn't want to have any organic residue left on the hardware, thought we could use UPW. So we did. A note about the ultrapure water—UPW cannot be captured in a container and used at another location. The UPW reacts with container walls and soon is no longer ultrapure. Labs using UPW have to be attached to the circulating loop.

ROSS-NAZZAL: Were you briefing him on all of these developments as you were working on the clean room and the contamination plan?

ALLTON: He knew about the water, because we had switched over to cleaning lunar tools that way. We picked a cleanliness level, and what we would need to achieve that cleanliness level. Since it was similar to the semiconductor industry, Don Burnett was agreeable, because they had already been buying materials cleaned by the semiconductor industry for collectors and analyzing them. They were satisfied that they were clean enough. They were probably the cleanest anyone could get things in those days.

ROSS-NAZZAL: How far out had you been working on this clean room? Was it before they started building the spacecraft? Or was it as they were designing and building?

ALLTON: Genesis was initially proposed as Discovery Mission called Suess-Urey. Suess-Urey Mission did not get selected that time, but our sister sample return mission Stardust did. However, many elements of the solar wind mission had been already developed. We'd already written the contamination control plan, of which I was a major contributor. When another round of Discovery competition opened, the basic elements of Suess-Urey plus improvements were submitted under the name Genesis, something that sounded more attractive, I guess. A lot of the Phase A work was already done.

We had already thought about how to do this clean room, so when it was selected late in 1997 it was a matter of getting the Center (JSC) to support the facility, which Eileen Stansbery negotiated and is most knowledgeable about those details. JSC provided engineering support and funding for preparing an existing room in 31N into which a Class 10 cleanroom could be placed. The cost was very modest, since we were just setting a clean room inside of an existing room.

ROSS-NAZZAL: The whole mission wasn't that expensive. I saw the cost. It's very modest, especially compared to a Space Shuttle flight.

ALLTON: Oh, yes. But what made it really go was the four or five of us were just all persnickety. We were after every detail. To prepare a clean room for this mission and to permit good analyses at that low sensitivity level, you have to watch all the details, and sometimes that's not really appreciated.

ROSS-NAZZAL: I'm sure some people, maybe facility people, got a little frustrated at times.

ALLTON: The facility people back in '98 and '99, they were a pleasure to work with. We explained what we were trying to do. We met with hands-on workers every morning. We took particle counts in the laboratories adjacent to where workers were preparing the room in which the Class 10 room would be placed. We'd say, "Okay, the particle count was this yesterday." So they knew we were measuring how much mess they were creating. Actually the particle counts were quite good, so that was encouraging. They were very careful. That worked very well.

What the JSC site people did, they created a lovely shell. The shell was coated with clean room paint, the flooring was cleanroom compatible, the incipient fire detection system installed, and the air handler ductwork was sealed to prevent shedding. It was beautiful and still is today. An outside contractor with expertise in cleanroom construction built the cleanroom inside of the shell room. The walls, raised floor, and ceiling were assembled from pre-made struts and panels. The Genesis cleanroom consisted of total ceiling coverage with ULPA fan filter units. There were 55 FFUs [fan filter units] all hung from the bottom deck of the Lunar Lab. This was a creative solution from the contractor to save space and maximize room size.

We got a fairly large size room in a small space. They knew what they were doing. Looking back, all that worked well, because we were meeting with them every day, monitoring the material composition, and explaining if we had concerns. I'm not sure you could do that on a larger scale.

ROSS-NAZZAL: How big is that room?

ALLTON: The lower elevation room is something like 20 feet by 10 feet. The upper room is 15 feet by 15 feet. There's a corridor that connects them on two levels. The original use for the rooms that became Genesis Lab included a public viewing room and restrooms. These rooms were dropped down two and a half feet lower to confine any water from the restrooms and prevent the water from entering lab areas where samples were handled. This was a wise original decision.

ROSS-NAZZAL: That makes sense.

ALLTON: The original Lunar Sample Building was well done.

ROSS-NAZZAL: You mentioned JPL coming out here. Did you have the opportunity to go out to JPL or Lockheed at any time?

ALLTON: I did not go to JPL or LMA during mission development. One reason is that I was extremely busy at JSC getting the cleanroom ready. Eileen participated in meetings at JPL as the principal JSC representative. I interacted more with JPL, Lockheed Martin, and UTTR in the interval after launch and getting ready for recovery. What we were going to do in Utah, and how to get ready for that. There was still more procedures that needed to be written. How did we want to document the handling environment at UTTR, witness plates, etc.? What was the process of retrieving the payload and the sample return capsule?

Genesis sample return capsule was scheduled to re-enter at UTTR at 10 a.m., September 8, 2004. The recovery plan called for a mid-air retrieval of the capsule. After the parachute was deployed, slowing down the descent, the parachute was to be snagged using a hook towed by a helicopter. The helicopter pilot was to snag the parachute, set it gently on the ground to secure it, and then fly the SRC to a clean room that we had set up nearby at UTTR. That cleanroom operated with a few HEPA FFUs and did not have a raised floor, so it was not the level of cleanliness in the JSC Genesis Lab. This cleanroom was placed at UTTR in order to saw open the SRC and put a nitrogen purge on the closed payload canister. Then the payload would go into a shipping box connected to a nitrogen cylinder. It would be transported under nitrogen purge all the way back to Houston, and only be opened when again back in the JSC clean room.

ROSS-NAZZAL: Didn’t quite work.

ALLTON: No it did not. That’s not what happened.

ROSS-NAZZAL: Did you all come up with that idea of that helicopter coming in and making that grab?

ALLTON: The Lockheed engineers had an interest and the right connections to work out the mid-air retrieval. Bob Corwin was the LMA lead engineer for the mid-air retrieval effort. He and some of the UTTR personnel had been fascinated with snagging stuff coming back from space, and there was military precedent for that with round parachutes. The parafoil, or gliding parachute, invented in 1967, offered a much safer and more reliable alternative. The right connection for Bob Corwin was Roy A. Haggard, who invented the flyby intercept method for military application in the early 1990s. Those two became good friends and evangelists for mid-air retrieval for Genesis. By the time I was involved in the UTTR portion of the recovery planning, the mid-air retrieval had been demonstrated many times, and it did look easy, due to the great skill of the pilots.

Cliff [Clifford T.] Fleming was a movie stunt pilot. He was a military veteran from, I think, probably Vietnam. We did get to watch them practice that. They never ever missed. It was so graceful; it was like a ballet in the sky. You'd think a re-entering spacecraft would be traveling a high velocity, so snagging that spacecraft parachute with a hook is going to be very hard to do. However, when the parafoil is deployed it slows down the capsule putting it into a big spiral, going about 20 miles an hour. So the prime helicopter and the backup helicopter both had several chances to make the snag, if missed. They never did miss.

The doors to the helicopter were removed so the crew could operate a winch from the "back seat." Cliff would lean out the window to get a good view of the target. He placed the hook just left of the centerline to make the snag. That would keep the parachute from flopping around. They practiced setting the SRC gently on the ground. But before the SRC was set down, the backup helicopter would first set out a clean tarp, to keep the SRC touching the dry lakebed. This interim set down, close to the snag site, was for the purpose of securing the SRC to the helicopter tow line. Then the SRC was towed to the cleanroom entry area and lowered into a cradle. Cliff could set the SRC down so gently in the practice runs. I just couldn't believe it.

I could look up and see the helicopter bouncing up and down [demonstrates], but the payload, the SRC, would be hanging straight and level, carefully and slowly lowered into the cradle. I do not know how they can do that, it was amazing, and that's what they practiced. Of course, they didn't get to do that, as it turned out.

ROSS-NAZZAL: Were you also practicing simulations in terms of getting the payload, taking it back, and putting it in the nitrogen purge? Were you doing any of those things, or were you primarily focused on procedures?

ALLTON: I was part of that rehearsal process. After the SRC was placed in the cradle, the cradle was to be rolled into the high bay. The next step was to have been sawing the latches open. This is one of those little "oops" things. There was no other way to open the capsule because they would have blown the hinge off to make a more aerodynamic entry. The plan was to take a saw and saw the latches off the outer capsule, the SRC.

My job was to run the vacuum cleaner with the filter so it could trap all the particles from sawing. We all had little jobs like that to rehearse. I think Eileen might have been a backup for the people prepared to use a sniffer. This was to check that there were no toxic fumes coming off of the SRC from reentry heating.

Then re-entry day arrived, September 8, 2004, 10 a.m. People at the Utah Test and Training Range and at Hill Air Force Base [Utah] were tracking the incoming capsule—they were actually calling out the altitude and the vector to Cliff and his crew and the second helicopter crew. They'd call out numbers of the altitude and the vector. The rest of us were watching this on long-range video, but the pilots weren't. All they could do was hear the call out.

The altitude numbers seemed to be dropping too fast to Roy [A.] Haggard who was in the cockpit with Cliff Fleming. Roy was uneasy. Then Range Control Officer Luke Topper at Hill Air Force Base said, "Impact." Cliff couldn't believe it. He asked Luke to repeat that.

ROSS-NAZZAL: What was the mood like in the room watching the video at that point?

ALLTON: I watched the re-entry sequence in the high bay of the building (Building 1112) at Dugway next to the cleanroom set up to receive the SRC. I was watching with the crew from JSC, LMA, and JPL who were prepared to open the SRC and, inside the cleanroom, put the nitrogen purge on the sample canister. We watched the capsule tumble downward and smack into the dry lakebed. Our heads turned toward the storage cabinets where we had placed kits for collecting shards off the desert floor, if the recovery did not go as planned. We were already looking at the cabinets, wanting to get the collecting kits, and go to the crash site to recover the collectors. These kits were buckets with pre-numbered containers, mostly bags, gloves, tweezers for cleanly picking up shards, but also included a camera, scale bar, and notebooks.

ROSS-NAZZAL: So you had worked on those contingency plans just in case?

ALLTON: Yes, I brought terrain maps in case we needed them, but the people at Hill Air Force Base, they had their own maps too. I had written a documentation plan, which contained a section on documenting samples collected under this unhappy circumstance of scattered shards. Yes, we were ready for that. I'm not sure all the managers were ready for us to go out there. It took a while for that to settle out, and we workers had to obtain permission to go to the site and start recovering material.

ROSS-NAZZAL: Oh, really? Why was that the case, do you think?

ALLTON: I'm not sure.

ROSS-NAZZAL: I'm sure as a scientist you were ready to get out there.

ALLTON: We knew what we wanted to do. I guess they wanted to double-check everything, which I thought would have been done already. I am sure those discussions were interesting.

ROSS-NAZZAL: How did you go out and capture this material? Did you have to suit up? Or you could just go out dressed as we are today?

ALLTON: We were dressed very casually because it was hot, and we expected to be working in the cleanroom covered with smocks, hats, gloves, and shoe covers. The team that went to the crash site to recover the science canister and contents consisted of personnel from LMA, who designed the SRC, JPL, who designed the payload, and one person, Karen [N.] McNamara, from JSC representing curation. The field people were the people who knew the hardware best, and Karen served to instruct everyone the best way to recover and document the samples. The field team was in contact with Don Burnett and Genesis managers via radio to collaborate on decisions regarding the salvage operation.

The field team rode to the crash site in vans. The UTTR road floats on the mud, and the capsule landed not that far off the road. McNamara had the collecting kits and instructed the field team members in how to document the collector pieces gathered at the crash site. The Lockheed people had to safe the pyros [pyrotechnics] that were not yet exploded. These pyros should have deployed the parachute. LMA people had to do sniffing tests for toxic gases and get a safety clearance.

The SRC capsule had hit the ground "edge on," like a dinner plate one third buried. Even though the lakebed was moist, and thus soft, the buried part of the SRC shell was mostly turned to powder. The field team started taking the outer capsule apart. Those of us near the cleanroom watched the fieldwork on long range video provided by UTTR. The canister containing the collectors was itself breached, it was broken. The bottom had been sheared off. After consultation with PI Burnett and Curation Manager Eileen Stansbery by radio, it was decided to roll the canister over onto a blue tarp, topside down because the canister cover was still intact. This configuration captured most of the collector fragments. It was overwrapped in a second tarp, put aboard an Army Blackhawk helicopter, and flown back to the building with the cleanroom. The big black helicopter was larger than Cliff's little red one. I was in the cleanroom area when the Blackhawk arrived with tarp-wrapped canister, before sunset.

ROSS-NAZZAL: How long did that process take?

ALLTON: The field team had to wait a couple hours before they actually started picking up collector pieces—and they were still on long-range video, so we could watch them. The Army took out meals ready to eat for them to eat and water. It was hot out there on the dry lakebed. The Army folks knew what to do to help the recovery team. How long did that take? I'm thinking it was late afternoon by the time they got back to Building 1112, where the cleanroom was set up. The tarp-wrapped canister was rolled in. Over the next few hours there was some discussion as to whether the wrapped canister should be transported back to Houston for extraction of the individual collector pieces or whether to extract, photograph, and package the individual pieces at UTTR.

The decision was the loose pieces would get more damaged in transport unless they were stabilized. So that's what we did. We obtained tools for de-constructing the damaged canister so the collectors were accessible. We already had with us containers for 6,000 specimens. Our curation colleagues from Johnson Space Center arrived to document and package fragments. All of them were skilled in cleanroom work and handling astromaterial samples, so no on-the-job training was needed!

That was September 8, 2004, when Genesis reentered and had a "hard landing." Always a public affairs term. October 3, which was less than a month later, we flew everything back to Houston on the Gulfstream III and had all the samples in a cleanroom receiving area by afternoon. We spent that month in Utah picking fragments from the damaged canister, photographing, logging the individual pieces, and packaging collector pieces and hardware pieces. Some of the hardware pieces of the outer capsule went to Lockheed Martin first for use by the mishap investigation board. That was a separate activity, and Karen McNamara was the curation representative to that board. All the solar collectors and the payload canister came directly to JSC.

While we were in Utah, we photographed and packaged more than 10,000 pieces from the original 301. Some of those were jars of very tiny fragments. Pick a number, it could be 15,000, 20,000. I think we really got every collector fragment. The impact site ground was damp and soft. The outer capsule was about 60 inches across. It hit edge on, so the half portion that buried was destroyed, even though the impact area was quite small, maybe 3 diameters of the capsule. Karen McNamara and some of the Lockheed people went back a second day and actually shoveled up 15 to 20 buckets of sand containing debris. So, I really think we got nearly everything from the spacecraft. We went through some of those buckets recently. We got rid of the mud.

ROSS-NAZZAL: Did you find anything in the dirt?

ALLTON: Yes, a lot of it was not too useful. Then there were some collector fragments we pulled from the mud, which had been sitting in wet mud for 10 years or so. So we salvaged some of that, but we did finally discard some of the mud and crash debris that we had saved.

We do have samples of lakebed sediments that were taken right before re-entry, which serves as reference material. We still have those. People have asked for samples of the Utah dirt, because they're trying to distinguish between Utah dirt and solar wind. They have a basis for making that distinction. We do have those kind of samples. Curation-wise, we keep samples of reference materials, that would be anything that might contaminate the collectors.

ROSS-NAZZAL: What did you package everything in? Did you package it in plastic or glass?

ALLTON: Pretty much plastic. We did have some glass jars. We used a lot of plastic vials, because that's what's used with some lunar samples that have been returned. Our cleaning process for hardware at JSC uses ultrapure water. Lots of plastic vials are cleaned to a high level of cleanliness and packaged. Since we are able to produce a lot of those, we sent several thousand vials to UTTR ahead of time.

We also could call our JSC colleagues and ask for additional supplies to be sent to UTTR. The wonders of the government credit card! The whole JSC team was very responsive. Everybody said, "What can I do to help?" We'd call JSC and say, "We need this, this, and this." It would show up the next day in a FedEx [Corp.] truck. At first I was wondering if FedEx delivered packages to the Utah Test and Training Range which is relatively remote, and I found out they do deliver there very promptly. We received clean packaging supplies this way.

Same way with JPL. They needed different tools and hardware because their job was disassembling the mangled mess of the science canister. First thing they did, was drive to Home Depot [Inc.] in Salt Lake City. One tool they purchased was a large bolt cutter. I too went to Salt Lake City to the restaurant supply place and Sam's Club for things that we still needed more of like stainless steel tables. The JPL engineers could call back to JPL and say, "I need X."

Everybody was sending things we needed, delivered the very next day. With a government credit card, a telephone, and FedEx, we got everything that we needed.

A side note here on an image that remains in my mind. UTTR is isolated and the nearest cell phone tower, at that time, was atop Deseret Peak 30 miles distant, for which we had line of sight from the parking lot. Cell phones were not ubiquitous. To make those phone calls to request supplies, one had to stand in the parking lot. At any given time, 4-5 people would be in the parking lot with a phone to their ear, spread out for privacy, and trying to write using a knee for a table. Even the science team from around the world offered encouragement and help. Many of them emailed, said, "We're going to do our best to make this analysis." This encouragement was from investigators who had invested 5 to 10 years preparing for this mission.

ROSS-NAZZAL: Were you originally planning on taking the Gulfstream back with these samples, or were you going to fly commercial?

ALLTON: Had the crash not happened, the science canister was to be placed on nitrogen purge and shipped in a large metal crate equipped with a nitrogen cylinder. I think it was going to go by truck but maybe cargo plane. By October 3rd we had all of the collector pieces and canister hardware packed for transport in metal cases. The managers requested the Gulfstream as a "gentle" transport to keep from further damaging the collectors. Carol [M.] Schwarz and I were selected to escort those samples, and of course we agreed! It was my first ride in the Gulfstream.

ROSS-NAZZAL: How did you get the Gulfstream? That's a unique opportunity. Not everyone gets to fly on that plane.

ALLTON: It was partly a perk for having stayed out there over a month and working long hours.

ROSS-NAZZAL: It's just for Center leadership, isn't it, pretty much, the Gulfstream? At least it seems like it.

ALLTON: I think we had an astronaut pilot.

ROSS-NAZZAL: Oh, cool.

ALLTON: It was cool.

ROSS-NAZZAL: What was the reception like here when you finally came back? The Building 31 crew and then the Center as well. Do you remember?

ALLTON: I remember we landed in a horrid rainstorm at Ellington [Airport, Houston, Texas]. Then we just unloaded the plane, and it must have been vans. I cannot remember that. It was a short trip from Ellington. We had a clean room we had set up for space-exposed hardware, so that's where we put the boxes that we had unloaded from the Gulfstream at Ellington. Then a portion of those were moved into Genesis Lab.

Lisa [A.] Fletcher (now Lisa Pace) had done an excellent job of logging thousands of samples in Utah. We had prenumbered tags with all these vials. We had a numbering system set up ahead of time for all this, so we had all these numbers to put on clean vials and whatever we put stuff in. All that was in a database, it was all logged in there in Utah, so we could check it out when we got back.

ROSS-NAZZAL: What did you start when you came back? Were you immediately cataloging or curating?

ALLTON: I'm going to digress here a little bit. If things had gone perfectly, some of us would have had to fly back and stay up all night cleaning more tools to get ready for examination and storage of samples, because there was just too much to do.

The landing changed all that, so we didn't have to do those special examinations of complete hexagons. It gave us a little time to think about it. We got samples into a dry nitrogen environment, for the most part, and we already had a database set up, with our numbering scheme, but now we had a little bit different data problem. We had some things like that to work out.

We got the samples back here in the JSC lab in October. We wrote some abstracts announcing the condition of the collection that were submitted in January, so that was part of it. I think the one I did was based a lot on notes we took in Utah. We were able to announce that we had samples for scientists to request before the Lunar and Planetary Science Conference [LPSC] in 2005.

ROSS-NAZZAL: That quickly?

ALLTON: Yes. Now some of the experiments were for certain PIs. One of them had flown gold foil to look for nitrogen, another one flew a polished aluminum piece to look at noble gases. So we subdivided those materials in time for the abstracts that year. That's what we would have been doing in the November, December timeframe.

For instance, Alex [Alexander P.] Meshik came from Washington University [St. Louis, Missouri] to JSC, and we cut the polished aluminum up. He took some pieces back to his laboratory. We cut the gold foil—that might have been a little bit later, the timing on that. But we did announce it, I think, at the end of February and before LPSC of that year. In April, the LANL concentrator team came to JSC and we finished removing the concentrator target quadrants from the mounting. This included the silicon carbide target in which the oxygen isotopes were determined. In 2007, we sent that sample to Kevin [D.] McKeegan at UCLA [University of California, Los Angeles], who did the analysis, and presented preliminary results at LPSC in 2009.

ROSS-NAZZAL: Tell me how you handle the samples. I've been in 31, and you see the glove boxes and handling. Do you have something similar for these samples, or are they just out on tables?

ALLTON: The samples are stored in nitrogen-purged cabinets within the Class 10 cleanroom where we also work on the samples. When we image or subdivide the samples, this work is done on stainless tables within the room. The samples have been exposed to Earth atmosphere when the canister broke open, but they're stored under dry nitrogen. People are fully suited up, and the tools that are used are cleaned with ultrapure water.

We've developed the capability to take those pieces that have fine debris on them and wash them with ultrapure water. We can wash away the loose micron, submicron size particles, and that helps people with their analyses. We don't clean samples routinely, because there is a worry that the water might change something.

The analyses so far—when they use beam instruments to measure solar wind—seem to indicate that that cleaning with ultrapure water does not do much damage, and it is more beneficial. But that would be the call of the person who wants to make the analysis if he would like us to clean them off with the water, so we can do that.

I guess one difference with Genesis—part of the science team has helped try and figure out how to clean these things. We send samples back and forth to people who might have a cleaning proposal for a protocol to try. We do have numerous small pieces that can be used for that purpose. It's probably a good use of those pieces. The oversight committee is aware of all this and keeps tabs on how this is done.

For UPW cleaning of samples, picture the room: stainless steel table and stainless steel tweezers. Samples are placed on a little vacuum chuck and held under megasonically-energized UPW. The sample is spun at 3,000 rpm [revolutions per minute] under the flowing water. It's a semiconductor device that we adapted for cleaning off these small parts.

ROSS-NAZZAL: How does that work so you don't get rid of those small grains of that solar wind?

ALLTON: The atoms of the solar wind hit the collectors with such high energy they're implanted a little below the surface, say under 100 nanometers (nm). The peak might be 40 nm deep or 20, which isn't very much. Chemical changes on the surface from cleaning might affect atoms at that shallow depth, so care must be taken. Plus, dings or scratches from the crash debris can be deeper than the solar wind.

We're lucky in that a lot of the analytical techniques use an ion beam to drill into the collector, knocking off solar atoms that can be measured in a mass spec [spectrometer]. The area analyzed this way is quite small, less than 100 microns wide. Therefore, the analyst can pick a location on the fragment without scratches or gouges. Even so there are problems if there's contamination on the top surface. The ion beam can garden the contaminant further into the surface. Investigators found a clever way around this problem. The collector fragment is glued face down (solar wind side down), and the ion beam analysis is performed from the back side, thereby measuring the solar wind before the contaminant is encountered. Investigators are getting more successful at that. This example illustrates a very important advantage of returning samples to Earth for analysis—many more options for recovering from disaster, like crashes or malfunctions.

ROSS-NAZZAL: How many of the samples have been used? Are there some like the Apollo rocks that have been set aside and will remain pristine for generations to come?

ALLTON: I'd like to acknowledge that setting aside portions of Apollo samples for future generations was a very wise thing to do. All of the astromaterial collections do this, generally by choosing a portion to be set aside, stored sealed under nitrogen, and a subset stored in a remote place. A year or two after sample return, about 2006, representative samples for each solar wind regime and each array collector material were preserved in a vault in a remote location from JSC. For the samples remaining as JSC, Genesis has a complicated sample retention plan that allows the portions to be retained recalculated periodically, based on the idea that these samples may have a shelf life, which is unknown. The solar wind atoms are embedded in the crystal structure of the collector. They could diffuse out with long periods of time.

Fifteen different materials were flown to collect solar wind. The materials on the passive collector arrays, flown as hexagonal shapes polished like mirrors—very beautiful—were mostly pure silicon. Others were diamond on silicon, sapphire, aluminum on sapphire, gold on sapphire, silicon on sapphire and germanium. These 300 hexagons were distributed over 5 arrays. Two of these arrays collected solar wind atoms for the entire exposure time of 27 months. We called those samples bulk solar wind. The solar wind isn't constant, but changes character with time among 3 conditions, or regimes, as distinguished by the Genesis spacecraft: interstream slow speed, high speed, or coronal mass ejections (CME). The CMEs are sporadic burps of material. Because of the suggestions, and perhaps insistence, to Don Burnett by Marcia Neugebauer during the very early mission concept discussions, the Genesis spacecraft was designed to capture separately these 3 regimes on individual arrays.

The separate arrays for each regime allows investigators to measure differences in chemical and isotopic composition and fluence among solar wind regimes. The deployment of the regime arrays was mutually exclusive, and each regime collected solar wind for roughly one third of the total exposure. Had Genesis not crashed, the identification of the regime hexagon collectors would have been straightforward. Because of the crash, what we recovered was a jumble of fragments dislodged from the array frames. However, we can tell from which regime for each fragment because of clever planning. Bulk solar wind collectors are all 700 microns thick. Coronal mass ejections are 650 microns thick, high speed 600, low speed 550. So we just take a little tiny fragment and measure how thick it is, then we know which regime of the solar wind. Eileen Stansbery and Andy Stone deserve credit for implementing this mission saving idea.

The concentrator's target samples would be those that would be most judiciously saved for people that can make the very best measurements on it. There's one piece of silicon carbide from which UCLA determined the solar oxygen isotopes. Subsequently that same sample piece was sent to Bernard Marty in France [Centre de Recherches Pétrographiques et Géochimiques, Nancy Université], who measured the nitrogen isotopes. Neon isotopes were measured by a Swiss team. Much science was accomplished by sequentially sharing the sample among several research teams. Each team made their own little ion beam holes, resulting in a sample appearance with a many small square shallow pits. Sharing is another alternative to subdividing samples.

ROSS-NAZZAL: Who makes the decision on who gets the samples? Is there a committee? You mentioned an oversight committee. Are you part of that team?

ALLTON: The request for Genesis research samples comes to me as curator. I acknowledge receipt of the request and pass it along to the Genesis subcommittee of CAPTEM (Curation and Planning Team for Extraterrestrial Materials), a sample science advisory committee for NASA. The Genesis subcommittee is composed of active or emeritus Genesis scientists, and I provide to them information about sample availability. They render a finding about the scientific merit and recommendation about allocating sample, which I forward to the program scientists at NASA Headquarters [Washington, DC] for concurrence. As curator, I'm allowed to make a few direct allocations of small samples for cleaning studies. That's just to speed things up. The overarching goal of this review process is to assure good science use of samples and fair access among researchers.

The Genesis sample allocation process is less formal than the larger collections like Apollo and Antarctic meteorites, because it involves ongoing review via email or telecon, which includes conversational exchanges between curator and requestor to clarify information. In contrast, the larger collections have review committees that meet face-to-face twice a year and catalogs of samples from which the investigator requests a specific sample. A Genesis investigator typically requests a specific material from a specific regime for which the curator searches for sample candidates for discussion.

ROSS-NAZZAL: What have we learned from Genesis? Have there been any big questions answered?

ALLTON: Let me start by saying that Genesis mission highest priority science goal was determination of the oxygen isotopic composition of the Sun, and that was achieved. The general science goal was to determine the precise composition of the solar nebula—the gas and dust that coalesced into the Sun and planets, with the Sun retaining more than 99% of the original starting material. Until Genesis, the composition of the solar nebula was measured by precision analyses of primitive, first-formed minerals found in oldest meteorites and assuming this was original composition of the solar nebula. Genesis people contended that the best measurement of the starting material for the Sun and planets would be obtained directly analyzing solar material in the best laboratories on Earth; hence, the Genesis spacecraft set out to capture solar material and return it to Earth. The oxygen isotopic composition was surprising because it was not like the Earth's, lending support, along with Stardust cometary analysis, to a more turbulent history in the early solar system.

Until now, people were concentrating on bulk solar wind analysis because there's more solar wind available to measure in these samples. The newest thing is people looking at regime samples. It turns out in 2003, at the end of October, they had a whopping series of coronal mass ejections [CME] over a few days. In fact, the CME energy went off scale from some of the other robotic spacecraft that detect these things, causing some to go into "safe" mode. Genesis just happened to have a coronal mass ejection array out which captured this big, energetic burp of solar material. These energetic CMEs became known as the Halloween storms, and Genesis has samples of this solar material that can be measured in the laboratory.

I'm optimistic that somehow we'll make more connections with the heliophysicists because solar atoms captured in the different Genesis regime samples should contribute to ideas about mechanisms for how the Sun operates. That wasn't really the primary purpose of Genesis mission. Genesis was for planetary science. However, Genesis data may also help solar physics people of this generation, like those using Parker Solar Probe data, perhaps.

Marcia Neugebauer, heliophysicist at JPL and early Suess-Urey/Genesis mission contributor, was the first person to use Mariner [Program] data to make solar wind measurements. I think it was Marcia that convinced Don Burnett that he needed to take the solar wind regimes as separate samples. It didn't seem to be that much of an add-on for design of the mechanisms, because altogether Genesis had very simple mechanisms. People worry about reliability of robotic missions, and this was a fairly simple spacecraft. All those mechanisms worked well in flight.

ROSS-NAZZAL: I had forgotten to ask you. Did you go out and see the launch at the Cape [Canaveral, Florida]? Did you get a chance to see that?

ALLTON: I went to the Cape to see it launch, but we didn't launch that day, or the next, and I came home. Eileen was the only one from our team who stayed the rest of the week.

ROSS-NAZZAL: That's disappointing.

ALLTON: We hustled to get Genesis out the door to Denver, so it could be integrated onto the spacecraft in August of 2000. Then we had to sit and wait a whole year, because there was a Mars launch of some kind that needed that launch window.

ROSS-NAZZAL: Hurry up and wait, I guess.

ALLTON: Hurry up and wait.

ROSS-NAZZAL: How many people are working in the lab these days?

ALLTON: There's two people that we call processors that work with the samples, and they're doing inventory as we speak.

ROSS-NAZZAL: That sounds like fun. What do you think your biggest challenge is working with the Genesis Program, from the time you started working on the contamination control plan until today? Do you have any major challenges?

ALLTON: I have to say, I think we all had it lucky. The team worked well together. When I look at other missions and other teams—Don Burnett is the principal reason for this. He still holds a meeting every year of the people who are interested in working on Genesis samples. Many of the people that come are back from the original team. He refers to the team as family. In recovering from the crash, he asked people to collaborate who might normally be competing. They did. One, because they respected Don, and two, they wanted to help salvage the mission science. And I'm beginning to see that it's unusual for relationships to work that well.

The annual gathering of the science team family is about 40 researchers today. In the 8-10 years after sample return, the team photos show about 80 people. Don once estimated 100 scientists have participated on the science team. There were strong bonds of friendship among the engineers, scientists, and curators that outlasted the mission status of Genesis.

On the 5th anniversary of sample return, about 20 people—many were technicians who helped salvage the samples from the desert floor—made a pilgrimage to UTTR to set a steel obelisk bearing the name "Genesis" and "September 8, 2004" to mark the landing spot. Inside the obelisk a time capsule was placed. The contents are mission documents and procedures, including a video of mid-air retrieval practice. JPL Genesis Project Manager Don Sweetnam personally commissioned the making of the marker. Now retired, Don Sweetnam still follows the Genesis science results.

ROSS-NAZZAL: You attribute that to Don? Or were there other factors?

ALLTON: Mostly to Don.

ROSS-NAZZAL: Probably holds a special place in your heart then.

ALLTON: Yes.

ROSS-NAZZAL: What do you think was your most significant contribution to the Genesis Program?

ALLTON: I guess overall I'm kind of a stickler for looking at the composition of everything that goes into the lab and checking it. But I could say they kind of hold me responsible for having them send 6,000 containers to Utah, just in case.

ROSS-NAZZAL: Were you a Girl Scout? That was good contingency planning on your part.

ALLTON: Yes, we ran that one out as much as we could ahead of time.

ROSS-NAZZAL: I think that we have exhausted my questions. I wasn't sure—might there be something else that you want to talk about in relation to Genesis?

ALLTON: No, because we touched on the future, and I'm hoping that solar physics people, that we can be of service to them. I don't know at what rate samples ought to be used up. I come from a background of being extremely stingy with samples from lunar days, but I also realize that these samples may not always be perfect.

ROSS-NAZZAL: Yes, that's important to know. Thank you so much for coming over today, I really appreciate it.

[End of interview]